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Dose calibration of the Tomotherapy treatment planning system based on a static tomotherapy plan

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Purpose/Objective: The dose calibration of the tomotherapy system consists on the comparison of the dose calculated by the treatment planning system (TPS) with that measured on a cylindrical Virtual Water phantom for a clinical plan. This method depends on the accuracy of the density curve of the CT as well as on the consistency of the phantom within time. In this work we have developed a static tomotherapy (TomoDirect) plan delivered on a water phantom which allows us to apply the TG-148 protocol on absolute dose measurement of static fields in tomotherapy and compare it with the dose rate output of the machine modelled in the TPS.
Materials and Methods: The plan consisted on the contouring of a rectangular region of interest (ROI) of dimensions 15x40x20 cm^3 to which a density of 1g/cm^3 was assigned. This ROI is placed centered at the isocenter of the machine. Inside, another ROI was contoured at the isocenter in order to use it as a target during the planning process. The dimensions of this ROI were 10 cm long at the transversal direction and 1 pixel in all the other directions. A TomoDirect plan was created with two opposite beams at 0° and 180° gantry angles with a jaw width of 5cm. Full dose and final dose calculations were performed after the first iteration of the optimization process, leading to a plan with two identical and very low modulated beams witha field size of 5x10cm^2. Hence, TG-148 can be applied and k_{qq0} can be obtained from the method suggested by Thomas et al (Med Phys 2005 May; 32(5):1346-53). The beam at 0° was measured in a rectangular Virtual Water phantom whose geometry equals that of the ROI in the plan. Previously, equivalency between the phantom and water at that point was checked. The results obtained were then compared with the reference dose established during the acceptance of the system and with the expected dose rate calculated based on the energy fluence per ideal open time(EFIOT) included in the TPS.
Results: Difference between dose calculated by the TPS and that measured was within a 0.1% once the dose was corrected by our reference dose rate, which was set during the acceptance of the system. These results suggest that the reference dose rate of our system with a 5x40cm^2field at a1.5cm depth and SSD 85cm should be 837 cGy/min. Given that the EFIOT stored in our TPS has a value of 3.4767x10^{10} MeV/$cm^{2,}$ the theoretical dose rate should be 855.6 cGy/min. Therefore, a discrepancy of a 1% was found. Results of this work show that a factor can be established between the dose rate stored at the TPS (EIOF) and that measured in a static reference field. This factor has a value of 4.0124x10^{-10}cGy.cm^2/MeV.
Conclusions: A direct relationship was obtained between the dose rate data stored in the TPS and that measured in a static beam in reference conditions. The factor obtained between these two parameters could be useful in the calibration of any Tomotherapy unit.

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Commissioning and initial experience with dosimetry check, an in vivo volumetric commercial software

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Purpose/Objective: DosimetryCheck (DC) (Math Resolutions) is a commercial EPID based dosimetry software, which allows performing pre-treatment and transit dosimetry. DC provides *invivo* 3D dose which can be displayed on the CT of the patient and provides an independent verification of the treatment, being potentially of great interest due to the high benefits of the *in vivo* volumetric dosimetry, which guarantee the treatment delivery and anatomy constancy. The aim of this work is to study the differences of reference point doses between DC and TPS to establish an accuracy level of the system.
Materials and Methods: We used DC v.3.8 with the EPIDs of two Varian iX. TPS was Eclipse v.10.0 with AAA algorithm. DC employs pencil beam algorithm. DC settings require a series of EPID integrated images acquired with increasing thicknesses of water interposed in the beam. Two specifically designed methacrylate tanks were built for that purpose. To test theresults of DC two phantoms were used: MP1 Water Tank and Solid Octavius 4D cylindrical phantom (PTW). Several plans were generated: (1) Four-field plan with MP1 base in contact with the couch (no air gap); (2) Four-field plan with MP1base 7 cm above the couch; (3) Four-field plan over Octavius 4D; (4) A 360° arc over Octavius 4D. In all cases field size was 10×10 cm^2 with 6 MV and 200 MU per field. Both in pre-treatment mode and during treatment, portal images were acquired in integrated mode for each static field or cine acquisition for arcs. For pre-treatment mode we used SID 105 cm and for transit mode 150 cm. Additional measurements were taken separately with a Farmer ion chamber mounted in MP1 to check TPS calculation.
Results: Agreement between TPS and ion chamber at isocentre for each single field was better than1%. Differences of reference point doses between DC and the TPS are shown in table 1. Total dose differences are less than 2%, but single field contributions may achieve values higher than 5%.

	Plan							
	1		2		3		4	
	Pre	Transit	Pre	Transit	Pre	Transit	Pre	Transit
Total dose difference between DC and TPS at isocenter (%)	-0.6	+1.6	-0.6	+1.2	-1.5	-0.8	-1.5	-0.2
Largest dose difference for the single field contributions between DC and TPS at isocenter (%)	-0.8	+2.6	-0.7	+3.4	-2.3	-5.8	---	---

Table 1. Differences of reference point doses between DC and the TPS.

In transit mode, DC gave unexpected results for fields directly affected by the table. Inplan 1, without air gap, the 180°-field resulted in equal dose at isocenter than 0°, for the same MU. In plans 2 and 3, both with air gap, the 180°-field resulted in even more dose at isocenter than 0°.
DC seems not to consider properly the effect of couch attenuation, especially when there is an air gap between phantom and couch, which could be the case for patients with vacuum mattress.
Conclusions: The tests carried out with simple plans suggest that the accuracy of DC achieves 2% for total dose. However, the study of the contribution from each single field shows greater differences. For off-axis dose distribution and logically for patients this uncertainty will result significantly higher. In any case the possibility of this evaluation and the potentiality of this new system have a very positive impact on improving patient QA. Currently DC system is being used with patients and results and uncertainties associated are under evaluation.

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Performance evaluation of 2D and 3D diode array in VMAT verification plan

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Purpose/Objective: This study was to evaluate the performance of 2D diode array (MapCHECK2,Sun Nuclear) mounted on the Isocentric Mounting Fixture (IMF) compared with 3D diode array (ArcCHECK, Sun Nuclear) for Volumetric Modulated Arc Therapy(VMAT) plan verification.
Materials and Methods: There were 4 Head-and-Neck (H&N) and 4 Prostate VMAT plans generated by Eclipse V8.9.17 treatment planning system and delivered by Varian Rapid Arc Clinac iX machine. VMAT patient plans were measured in actual beam angles by MapCHECK diode array with 1527 diode detectors at 5 cm water equivalent depth. MapCHECK array was mounted on the isocentric mounting fixture (IMF) and attached to the gantry of Rapid Arc machine. The same VMAT plans with actual beam angles were measured by ArcCHECK with 1386 diode detectors arranged in a spiral pattern with 10 mm sensor spacing. The agreement between VMAT plan (Eclipse calculation) and measurement was evaluated using gamma evaluation with 10% dose threshold and 3% absolute dose difference and 3mm distance to agreement(DTA). The performance of 2D array and 3D array for VMAT plan verification was evaluated by using the percentage of passing point between Eclipse plan and measurement.
Results: For all VMAT plans, the pass rate exceeded 95% using MapCHECK 2D array with IMF and 94% using ArcCHECK. The difference of % passing point between MapCHECK with IMF and ArcCHECK ranged between 0-2 % for each VMAT plan.